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Research Article

ARCHIVES OF
CLINICAL AND
BIOMEDICAL RESEARCH
ISSN: 2572-5017



# Increasing Numbers of Children Aged 5-19 Years with Memory Problems in Sweden and Norway

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## Abstract

Previous studies have reported negative impact on memory and cognitive functions in humans and animals from exposure to microwaves, also called radiofrequency (RF) radiation, emitted from wireless technology. In this register based study, data from the Norwegian Syndromic Surveillance System (NorSySS) on memory impairment (ICPC-2 code P20) in children aged 5-19 years during 2006 to 2024 were obtained. Similarly, from The Swedish National Board of Health and Welfare's national patient register on number of patients aged 5-19 years in specialized open care, diagnosed during 2001 and 2024 with codes related to memory problems or disturbances (R41.3, R41.8 or F06.7), were assessed. In Norway the consultations increased from 179.51 in 2006 to 1,522.40 per 100,000 inhabitants in 2024, representing an 8.5 times increase. The increase was especially pronounced in recent years. A similar trend was observed in Sweden with increasing yearly number of patients with mild cognitive impairment diagnosis (R41.8), particularly from 2010 with 0.86 patients to 51.531 patients per 100,000 inhabitants in 2024, thus an increase of nearly 60 times during that time period. During that time period children's exposure to microwave RF radiation has increased substantially. We postulate that this can be a causative factor for these increasing trends in consultations for memory problems in Norway and diagnosis of cognitive impairment, including memory problems, in Sweden.

**Keywords:** Radiofrequency radiation; Cognitive impairment; Memory; Childhood; Sweden; Norway

## Background

In June 2025 the Norwegian TV Channel NRK reported that memory problems among children aged 5-14 years had nearly tripled between 2019 and 2024 (https://www.nrk.no/buskerud/eksplosiv-okning_-barn-sliter-med-hukommelsen-1.17448953; In Norwegian language). This may be associated with increasing exposure to microwave radiation, also called radiofrequency (RF) radiation, from mobile phone technology since memory and concentration problems are among the most common symptoms reported as an effect from such exposure, as discussed in the following.

## Introduction

Mobile communication technologies emit pulse modulated microwave RF radiation. Microwaves are frequencies between 300 MHz and 300 GHz and it is within this frequency band that most mobile communication technologies operate.

Human exposure to such radiation has increased substantially during the

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**Citation:** Mona Nilsson, Lennart Hardell. Increasing Numbers of Children Aged 5-19 Years with Memory Problems in Sweden and Norway. Archives of Clinical and Biomedical Research. 9 (2025): 416-424.

**Received:** October 06, 2025
**Accepted:** October 10, 2025
**Published:** October 17, 2025

Mona Nilsson BSc and Lennart Hardell MD, PhD., Arch Clin Biomed Res 2025
DOI:10.26502/acbr.50170483

last decades due to much more intense use of mobile phones (also called smartphones), the deployment of 3G, 4G, and recently 5G base stations. In addition the use of Wi-Fi routers and other devices that communicate wirelessly with pulse modulated microwaves are also used more than before.

The deployment of 5G since 2019/2020 has led to a massive increase in human exposure to microwave RF radiation. We have published eight case studies [1-9] that show that the radiation levels have reached very high levels after 5G roll-out, far above those previously reported to cause negative health effects in humans living near mobile phone masts and base stations [10].

## Limits for Microwave RF radiation

In the late1990s, the Federal Communications Commission (FCC) in the USA (https://docs.fcc.gov/public/attachments/FCC-19-126A1_Rcd.pdf) and the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in Germany [11] adopted or recommended exposure limits that are based on thermal effects (tissue heating) only. These limits, although they are based on thermal acute effects, are claimed to protect the public and workers from negative health impacts of RF radiation. The International Commission on the Biological Effects of Electromagnetic Fields (ICBE-EMF) on the other hand concluded that "these limits were based on results from behavioral studies conducted in the 1980s involving 40–60 minutes exposures in 5 monkeys and 8 rats, and then applying arbitrary safety factors to an apparent threshold specific absorption rate (SAR) of 4 W/kg. The limits were also based on two major assumptions: any biological effects were due to excessive tissue heating and no effects would occur below the putative threshold SAR" [12].

These two assumptions (on tissue heating and the putative SAR threshold) have been shown in scientific results during the last two decades to be incorrect based on intensive research on health effects from pulse modulated microwave radiation. Numerous studies have convincingly and repeatedly shown negative health and other biological effects, for instance oxidative stress, DNA damage and harmful effects on the brain, well below the levels that cause thermal effects [12,13]. Nevertheless the limits recommended by ICNIRP are still endorsed by influential organizations such as the WHO, the EU Commission, and adopted by most countries around the world.

In 2020 ICNIRP modified the recommendations and relaxed them somewhat in spite of increasing critique [14] of their ability to protect against harm (www.emfscientist.org, https://www.emfcall.org/the-emf-call/). The ICNIRP limits are important to the telecommunications industry, that promotes and defends the limits and claim they "ensure the protection of people against all established health hazards" (https://www.gsma.com/solutions-and-impact/connectivity-for-good/public-policy/wp-content/uploads/2021/10/GSMA_International_EMF_Exposure_Guideline_Oct21.pdf). According to a leading 5G infrastructure provider (https://www.itu.int/en/ITU-T/Workshops-and-Seminars/20171205/Documents/S3_Christer_Tornevik.pdf) the 5G roll out would be difficult or impossible if the limits were 100 times lower.

## Impacts on the Brain and Nervous System

Already during the 1960s and 1970s harmful effects caused by exposure to pulsed or modulated microwave or RF-radiation were reported in the scientific literature. Scientists concluded that the function of the nervous system and the brain appeared to be primarily affected [15,16]. Investigations of exposed workers showed than microwave (RF) exposure at non–thermal levels caused symptoms such as fatigue, dizziness, headache, sleep disorders, anxiety, and problems related to attention and memory [17,18].

Together the primarily nervous system related symptoms were called the microwave syndrome, radiofrequency sickness or illness [10,15]. These non-thermal effects depend primarily on the modulation and/or pulsation of the signal and also on the peak and average intensity. Pulsed signals and simultaneous exposure to several frequencies caused more effects and were thus considered more hazardous. The observed effects increased with time of exposure [19,20].

A study of the personnel at the US Embassy in Moscow, in total 1,800 persons exposed to increased levels of microwave radiation, was conducted by scientist from the John Hopkins University during the 1970s. The study found that symptoms such as depression, irritation, concentration and memory problems were more prevalent among the embassy personnel than among the comparison group [15].

## Mobile Phone Mast and Base Station Health Effects

Studies investigating health effects among people living close to base station or mobile phone masts have reported increased prevalence of several of the same symptoms as those described above [10]. A study published in 2025, one of the largest conducted so far, also found increased prevalence of the microwave syndrome or radiofrequency sickness symptoms with increased measured microwave RF radiation in the investigated person's homes [21]. Although the levels in the highest exposure group (5,000–8,000 $\mu W/m^2$) were well below the ICNIRP and the FCC limits, over 90% of the participants in that group reported symptoms such as fatigue, sleeping problem, memory problems, headache, increased irritability, and anxiety.

Previously, a study on 217 male students aged 13-16 years attending schools with mobile phone base stations within 200 meters from the schools reported that the group with highest exposure (100.21 $mW/m^2$) had impaired spatial working memory, and attention [22].

Mona Nilsson BSc and Lennart Hardell MD, PhD., Arch Clin Biomed Res 2025
DOI:10.26502/acbr.50170483

The 5G technology started to be deployed in 2019/2020 with increasing numbers of base stations and antennas emitting microwave RF radiation. Eight case studies and a summary of seven of these case studies on people exposed to radiation from 5G base stations have been published, as mentioned previously. The most common and severe symptoms among the 16 studied persons were sleeping problems, fatigue, headache, and increased irritability. Also emotional, concentration/attention, and memory problems were prevalent [1-9].

## Mobile Phone Use and Memory Functions

Several studies on humans have reported that mobile phone use negatively impacts memory and cognitive functions.

A study on 147 children using mobile phones reported an increase in perception disorders, arbitrary and semantic memory, and increased fatigue. "A steady decline of the parameters from high values to bottom standards" was reported [23].

An association between estimated cumulative RF radiation brain dose and decreased memory scores was found in a study involving 843 teenagers in Switzerland. An association was observed for right side mobile phone users and decreased figural memory, as well as a decrease of verbal memory score seen in left-side users. This may be due to the lateralization of memory processes, as verbal memory has been related to the left part of the brain while figural or spatial memory to the right side [24].

Further, a study among undergraduates found that the presence of a smartphone could have a negative effect on learning and memory. The students without smartphones had higher recall accuracy compared to those with smartphones [25].

## Laboratory Studies

The hippocampus is related to learning and memory. Studies have found that microwave RF radiation can damage the hippocampus, including neuronal degeneration and apoptosis. Behavioral animal experiments related to the hippocampus' function have shown that RF microwave radiation caused decline in learning and memory abilities [26].

Many animal laboratory studies have reported harmful effects on memory and learning from exposure to microwave RF radiation. Already in 1994 a study exposing rats to pulsed 2450 MHz microwaves for 45 minutes reported that the exposure caused retarded learning indicating a negative impact on spatial working memory function [27]. Another study on rats, also exposed to pulsed 2450 MHz microwaves, found that one hour exposure caused decline in spatial "reference" memory [28]. A Swedish research group reported in 2008 that rats exposed to GSM 900 MHz radiation 2 hours per week during 55 weeks had significantly reduced memory functions [29].

The microwave frequencies 900, 1800 or 2450 MHz at levels well below ICNIRP limits caused decline in cognitive function, significant impairment in learning and memory, increase in HSP70 level, and DNA damage in brains of exposed rats. The rats were exposed during 90 days at SAR levels between $5.953 \times 10^{-4}$ W/kg and $6.672 \times 10^{-4}$ W/kg [30].

Microwave RF radiation exposure decreased learning and memory in the rats exposed to 2.45 GHz microwave radiation (continuous wave) for 2 h/day over a period of 40 days at 160 mW/m$^2$ or 0.017 W/kg, thus levels below the FCC and ICNIRP limits. It was further found that the neuronal density in a part of the hippocampus was significantly decreased [31].

A recent study exposed rats to both 2.8 and 9.3 GHz microwave radiation for 6 minutes at 100 W/m$^2$. A second group of rats was exposed to those frequencies sequentially during 6 minutes for each frequency. That exposure caused reduced learning and memory ability as well as changes in electroencephalogram (EEG), such as increased power of theta and delta waves, which may indicate brain dysfunction or even brain damage. Histopathological analysis found structural injuries in hippocampus after exposure, and most serious injuries were observed in the group of rats exposed simultaneously to both frequencies [32].

It was reported in another study on rats that 1.5 GHz and 4.3 GHz microwave radiation exposure caused cognitive impairment and tissue damage in the hippocampus. Exposure to both frequencies simultaneously also caused more serious effects than exposure to only one of the frequencies [33].

Several other studies on animals have also documented harmful effects on the brain such as on memory, cognitive functions, and the hippocampus from microwave RF exposure at frequencies used for Wi-Fi, at 2.45 GHz [34-40].

## Aim of the Study

The aim of this study was to investigate memory impairment in childhood based on official statistics in Norway and Sweden. Since the study was register based with no individual data, ethical approval was not necessary.

## Material and Methods

Statistics on memory impairment in children aged 5-19 years were obtained from The Norwegian Syndromic Surveillance System (NorSySS). This data base shows how many consultations there have been with a specific diagnosis at the country's general practitioners and out-of-hours primary care facilities. NorSySS therefore shows trends and possible outbreaks of a disease which may lead to more people contacting the physician. We obtained data on number of consultations for memory disturbance (ICPC-2 code P20) per 100,000 inhabitants each year from 2006 until

Mona Nilsson BSc and Lennart Hardell MD, PhD., Arch Clin Biomed Res 2025
DOI:10.26502/acbr.50170483

2024. It should be noted that a child may have had several consultations per year.

We also obtained data from The Swedish National Board of Health and Welfare's national patient register on number of patients in specialized outpatient care diagnosed with codes related to memory problems/disturbances. We obtained number of patients per 100,000 inhabitants aged 5-19 years diagnosed each year between 2001 and 2024 with the ICD codes R41.3, R41.8 or F06.7 as main diagnosis. Mostly these codes are used for patients with memory disturbances (https://www.internetmedicin.se/aldrepsykiatri/minnesstorningar-lindriga-kognitiva-symtom; In Swedish).

## Results

The data from Norway showed that there has been a clear increase in number of consultations among children aged 5-19 years seeking medical care for memory problems each year between 2006 and 2024, Table 1, Figure 1. The table and graph show that the number of consultations increased slowly between 2006 and 2019, from 179.51 per 100,000 inhabitants in 2006 to 512.50 per 100,000 inhabitants in 2019. Thereafter the consultations increased markedly and the upward trend was more rapid. In 2024 there were 1,522.40 consultations per 100,000 inhabitants which is almost three times more than in 2019 and 8.5 times more than in 2006.

**Table 1:** Consultations for memory problems (ICPC-2 code P20) among children aged 5-19 years per 100,000 inhabitants in Norway during 2006–2024.

| Year | Number/100,000 inhabitants |
|---|---|
| 2006 | 179.51 |
| 2007 | 222.30 |
| 2008 | 273.26 |
| 2009 | 291.65 |
| 2010 | 341.73 |
| 2011 | 346.61 |
| 2012 | 383.88 |
| 2013 | 383.09 |
| 2014 | 380.21 |
| 2015 | 398.82 |
| 2016 | 418.26 |
| 2017 | 441.18 |
| 2018 | 466.86 |
| 2019 | 512.50 |
| 2020 | 638.69 |
| 2021 | 928.86 |
| 2022 | 1156.60 |
| 2023 | 1367.73 |
| 2024 | 1522.40 |

**Table 2:** Number of patients aged 5-19 years, per 100,000 inhabitants, each year with R41.8, mild cognitive impairment, subjective, as main diagnosis in Sweden during 2001-2024.

| Year | Patients/100,000 inhabitants |
|---|---|
| 2001 | 0.55 |
| 2002 | 0.302 |
| 2003 | 0.279 |
| 2004 | 0.444 |
| 2005 | 0.365 |
| 2006 | 0.549 |
| 2007 | 0.49 |
| 2008 | 0.529 |
| 2009 | 0.749 |
| 2010 | 0.86 |
| 2011 | 5.652 |
| 2012 | 10.088 |
| 2013 | 9.549 |
| 2014 | 10.731 |
| 2015 | 14.811 |
| 2016 | 17.969 |
| 2017 | 18.754 |
| 2018 | 18.494 |
| 2019 | 25.514 |
| 2020 | 28.017 |
| 2021 | 33.361 |
| 2022 | 37.371 |
| 2023 | 38.307 |
| 2024 | 51.531 |

Data from Sweden shows rapidly increasing number of children aged 5-19 years diagnosed each year with R41.8 (mild cognitive impairment, subjective) that includes memory problems. Table 2 and Figure 2 show the number of children, per 100,000 inhabitants diagnosed with R41.8 as the main diagnosis. The number of children diagnosed with R41.8 has increased considerably from 2010, when 0.86 patients aged 5-19 years per 100,000 inhabitants were diagnosed, to 2024 when 51.531 patients aged 5-19 years per 100,000 inhabitants were diagnosed. There is a similarity between the trends in the two countries. Thus during the last 4-5 years there have been more rapid increasing numbers in both Norway and Sweden.

We also obtained Swedish data for children aged 5-19 years diagnosed with R41.3 (unspecified loss of memory) and F06.7 (mild cognitive disturbance, caused by disease or injury), but the numbers were very low, less than 20 patients per year, and no change over the years. Data not in table.

Mona Nilsson BSc and Lennart Hardell MD, PhD., Arch Clin Biomed Res 2025
DOI:10.26502/acbr.50170483

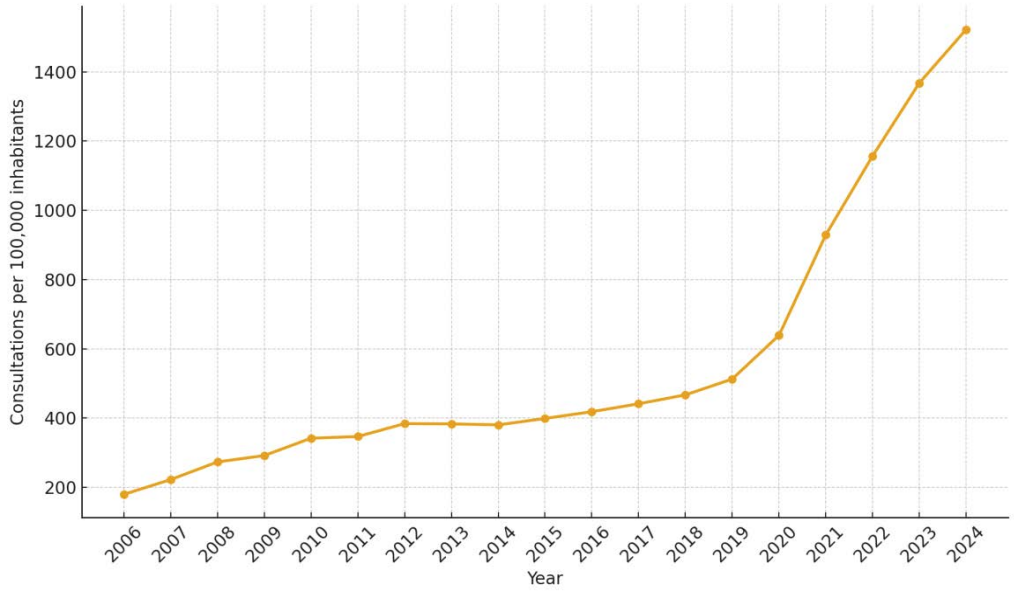



**Figure 1:** Consultations for memory problems (ICPC-2 code P20) among children aged 5-19 years per 100,000 inhabitants in Norway during 2006–2024.

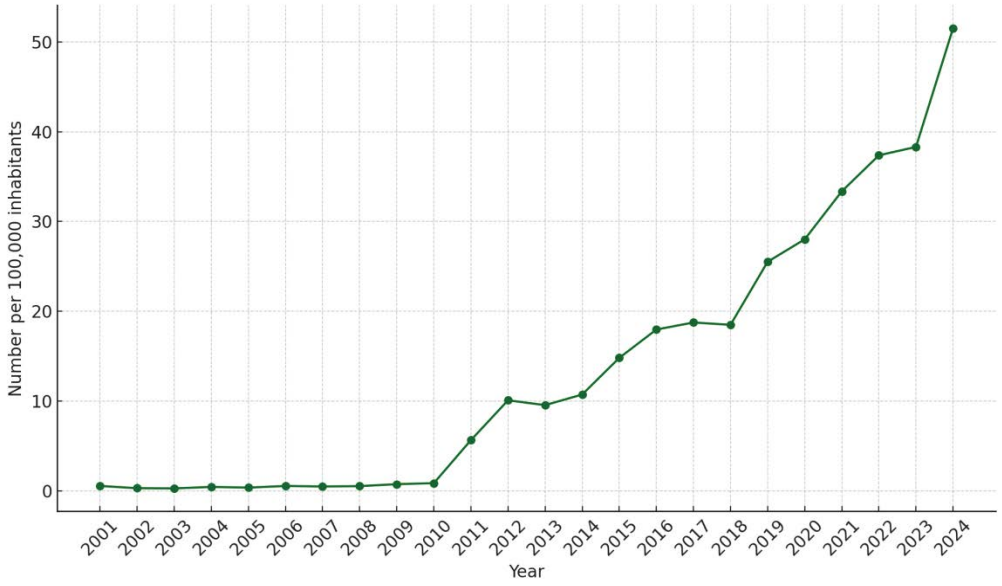



**Figure 2:** Number of patients aged 5-19 years per 100,000 inhabitants, each year with R41.8 mild cognitive impairment, subjective, as main diagnosis, in Sweden during 2001-2024.

## Discussion

The data presented here show very disturbing trend of a rapidly increasing number of children and teenagers consulting medical care for memory problems or diagnosed with mild cognitive impairment, in particular over the last five to 14 years in Norway and Sweden. The increase cannot be explained by changed diagnostic criteria or reporting frequency.

What changes in children's environment and life style might have contributed to this worrying trend of impaired memory and cognitive functions?

There are multiple reports, both from animal experimental studies and epidemiological studies on humans, showing that microwave RF radiation exposure negatively impacts memory and cognitive functions. The hippocampus in the brain is important for short and long term memory, learning, and spatial navigation [41,42]. Several animal studies have also reported damage to the hippocampus from exposure to

Mona Nilsson BSc and Lennart Hardell MD, PhD., Arch Clin Biomed Res 2025
DOI:10.26502/acbr.50170483

microwave RF radiation. Children's exposure to microwave RF radiation from wireless technologies such as smart phones, base stations/antennas, Wi-Fi-routers, smart meters, and other wireless technologies that emit microwave RF radiation has also increased rapidly during the same time period as the increasing number of children with decline in memory and cognitive functions.

**Table 3:** Factors related to children's increasing exposure to microwave RF radiation in Sweden 2008-2024.

| | |
|---|---|
| 2008 | IPhone smartphones were introduced in Sweden. They became rapidly popular as well as other smartphones (https://internetmuseum.se/utstallningar/for-unga/nar-vara-mobiltelefoner-plotsligt-blev-smarta/; In Swedish). Children's and teenager's use of mobile phones increased. In 2022 more than 70% of Swedish children aged 15 years used a smart phone for more than 3 hours per day. More than 40% of children aged 12 years used it more than 3 hours per day, see pages 42 and 56 in the report (https://mediemyndigheten.se/globalassets/rapporter-och-analyser/ungar-och-medier/ungar--medier-2023_anpassad.pdf; In Swedish). |
| 2009/2010 | 4G starts to be deployed. (https://sv.wikipedia.org/wiki/4G). |
| 2010 | IPads and other tablets are introduced in Sweden. (https://internetmuseum.se/utstallningar/for-unga/nar-vara-mobiltelefoner-plotsligt-blev-smarta/; In Swedish) |
| 2010 | Wi-Fi and wireless computers or tablets are increasingly used in Swedish schools. By 2016 most schools have Wi-Fi. (https://www.skolverket.se/sok-publikationer/publikationsserier/rapporter/2013/it-anvandning-och-it-kompetens-i-skolan?utm_source=chatgpt.com; In Swedish https://www.skolverket.se/download/18.6bfaca41169863e6a65c32a/1553966893852/pdf3667.pdf?utm_source=chatgpt.com; In Swedish) |
| 2016 | 4G+ starts to be deployed increasing the total microwave RF radiation exposure over the next years. (https://surfa.se/nu-kommer-4g-pa-bred-front-vi-forklarar/; In Swedish). |
| 2017 | Airpods are introduced in Sweden and are increasingly used over the following years among teenagers and children. The use of this and similar products leads to increased exposure to microwave RF radiation to the brain over longer time periods and also increased magnetic field exposure to the brain (50). |
| 2019/2020 | 5G roll out begins, causing much higher overall exposure to microwave RF radiation over the following years. |

Table 3 shows that between 2008 and today children's exposure to microwave RF radiation would be expected to have increased substantially through the introductions of smartphones, 4G and later 4G+, and 5G that each emits higher microwave RF radiation than previous systems [1-9,43,44]. Wi-Fi and wireless computers/tablets in schools and children's day care centers have been increasingly used as well as children's own use of mobile phones, wireless earbuds, and headsets. In 2022 more than 70% of Swedish children aged 15 years used a mobile phone more than 3 hours per day while among children aged 12 years more than 40% used a mobile phone more than 3 hours per day, see Table 3. The increasing use and exposure is of concern due to the risks of negative health consequences from microwave RF radiation.

According to a Swedish investigation 90 percent of children aged 11-19 years old used the smartphone on a daily basis in 2019 (https://svenskarnaochinternet.se/rapporter/barnen-och-internet-2019/vardagsanvandning-av-internet-11-19-ar/barnens-anvandning-av-enheter/; In Swedish).

5G was introduced in 2019/2020 and 5G base stations and antennas have been deployed during the following years causing a significant increase in people's exposure to microwave RF radiation [43-46]. The overall increasing exposure is also of concern regarding cancer risks associated with exposure to microwave RF radiation [47,48].

In our series of case studies we documented that the radiation levels from 5G increased more than 100 times compared with the exposure from previous generations of mobile phone technology, 3G and 4G [1-9]. We also documented that people who had tolerated exposure from 3G and 4G, rapidly developed microwave syndrome symptoms, including memory decline, shortly after 5G was deployed near their dwellings. Loss of immediate memory and concentration/attention deficiency were among the ten most common and worst graded symptoms among the 16 studied persons [9].

In a separate study in 2024 we documented very high levels of microwave RF radiation in the surroundings of ten schools in Sweden [49]. Since, in addition, wireless technology is used in schools it is assumed that children's exposure to RF radiation during school time is of major concern (https://www.skolverket.se/sok-publikationer/publikationsserier/rapporter/2013/it-anvandning-och-it-kompetens-i-skolan; In Swedish). It may be expected that a similar trend of increasing RF radiation occurred in Norway.

## Conclusion

This register based study shows increasing memory problems and/or cognitive impairment in children aged 5-19 years in Norway and Sweden. The increase is most dramatic during recent years. One etiological factor may be the increasing exposure to microwave RF radiation, that in several human and animal laboratory studies has been associated with impairment of memory and cognitive functions. Certainly these trends are of major concern. The public and the public health institutions should pay attention

Mona Nilsson BSc and Lennart Hardell MD, PhD., Arch Clin Biomed Res 2025
DOI:10.26502/acbr.50170483

to this emerging health issue and implement protective measures.

**Acknowledgements:** Not applicable.

**Funding:** No funding was received.

**Availability of data and materials:** The information generated and analyzed during the current study is available from the corresponding author on reasonable request.

**Author's contributions:** MN and LH contributed to the conception, design and writing of the manuscript. Both authors read and approved the final manuscript.

**Ethics approval and consent to participate:** Not applicable.

**Patient consent for publication:** Not applicable.

**Competing interests:** The authors declare that they have no competing interests.

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Mona Nilsson BSc and Lennart Hardell MD, PhD., Arch Clin Biomed Res 2025
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Mona Nilsson BSc and Lennart Hardell MD, PhD., Arch Clin Biomed Res 2025
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**Citation:** Mona Nilsson, Lennart Hardell. Increasing Numbers of Children Aged 5-19 Years with Memory Problems in Sweden and Norway. Archives of Clinical and Biomedical Research. 9 (2025): 416-424.